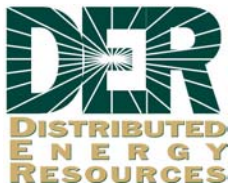


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# U.S. Department of Energy's Advanced Industrial Gas Turbines

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Merrill Smith  
U.S. Department of Energy



# Program Description

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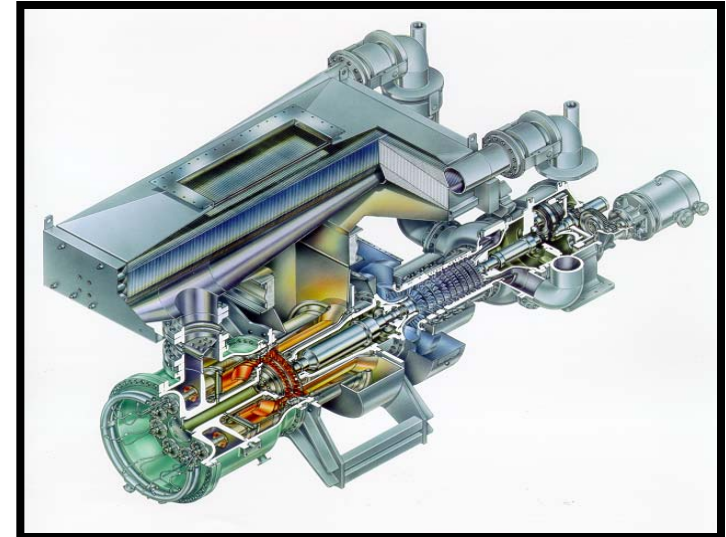


The Advanced Turbine Program is focused on lowering emissions and improving the performance of industrial gas turbines. This effort builds on the success of the Advanced Turbine System Program (ATS) that was completed in 2001. Gas turbines in the 1MW to 20MW size will play a critical role in the deployment of Distributed Energy Resources.

# Distributed Advanced Turbine Systems

**1992**

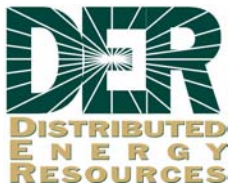
- **28% Efficiency (LHV)**
- **Double digit ppm NOx**



- **Advanced designs**
- **Lower cost operations**
- **Improved RAMD**

**2000**

- **40% Efficiency (LHV, Simple Cycle)**
- **> 80% Efficiency (CHP)**
- **Single Digit ppm NOx**
- **3.5 cents/kWh (8000hrs/yr)**



# Need Exists for Continued Government Investment in Turbines



## ***Significant Message from Industry***

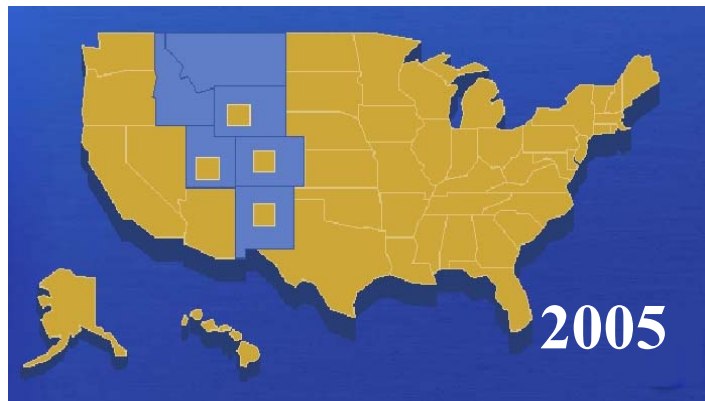
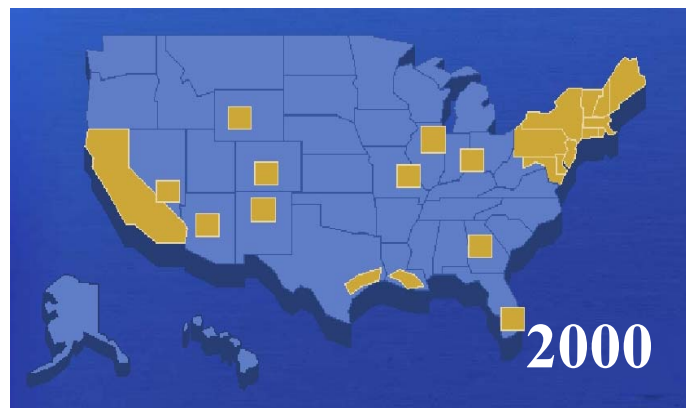
- Growing worldwide demand for electricity
- Tightening environmental requirements
- Declining R&D budgets in restructured U.S. electric industry
- Need flexible power generating technology
- Maintain U.S. leadership in multi-billion dollar global power market

# NOx Emissions Limits



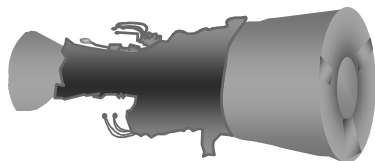
■  $> 25$  ppm

■  $< 5$  ppm



# Perspective on the Options

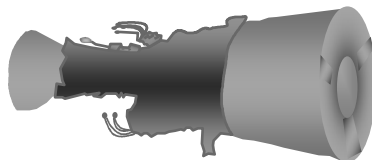
## Conventional Cleanup



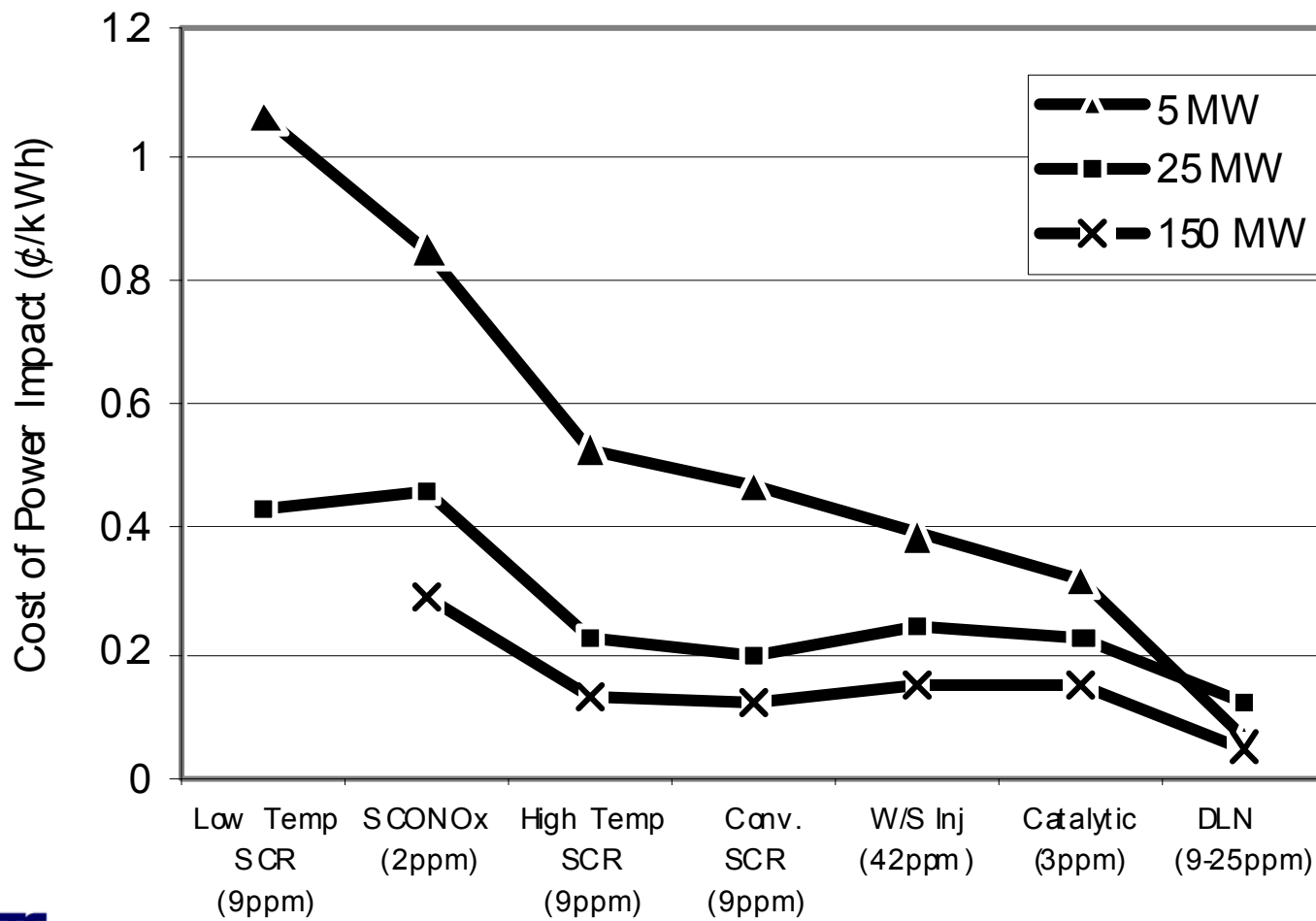
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## Emission Prevention

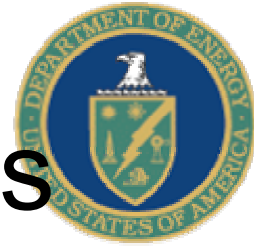


# Cost of NO<sub>x</sub> Control





# Gas Turbine Goals for Low Emissions and Materials



- Development of environmental and performance solutions for gas turbines that broaden opportunities for meeting the nation's energy demand with efficient, affordable, and reliable power.
- To reach this goal, bring together relevant stakeholders in strategic partnerships to develop, test, and commercialize optimized and fully integrated low-emission technologies and advanced materials.

# Performance Targets for Industrial Gas Turbines

- Advanced Materials
  - Improved efficiency & environmental performance
  - Elimination of cooling air > 2% gain in efficiency and lower emissions
  - Increase life/durability of new materials > 8000 hrs
  - Higher E/T that expands the market for combined heat and power
- Low Emissions Technologies
  - Target < 5 ppm NO<sub>x</sub>
  - Consideration for transition to back-up fuels
  - Durable for at least 8000 hours
  - No more than 10% cost add-on
  - No negative impacts on gas turbine performance

# Industrial Gas Turbines



**2000**

**Today's ATS**



- Low emissions technologies
- Advanced materials development

## 5 Low Emission Awards

- Precision Combustion Inc
- Catalytica
- Alzeta
- Solar Turbines
- Honeywell

## 4 Advanced Material Awards

- GE
- Teledyne
- Siemens Westinghouse
- Solar Turbines

(DOE funding \$13M over 3 years)

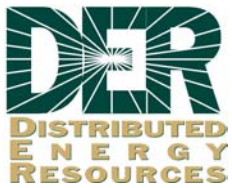
**2010**

<5 ppm NO<sub>x</sub>  
Improved performance  
< 10% cost add on  
>8000 hrs durability



# Materials Portfolio

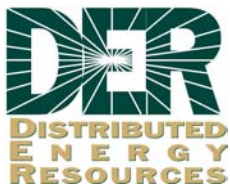
- Ceramic Matrix Composites (Continuous Fiber Ceramic Composites) including Environmental Barrier Coatings  
**Combustor Liners, Shrouds**
- Thermal Barrier Coatings  
**Blades, Vanes**
- Metal Alloys (powder nickel superalloys and titanium silicon carbide)  
**Inlet Nozzle, Rotor, Scroll**
- Oxide dispersion-strengthened alloys  
**Combustor Liners, Injector Tips**
- Monolithic ceramics  
**Injector Tips**



# Low Emissions Portfolio



- Lean Premix Combustion
- Catalytic Combustion
- Surface Stabilized Combustion



# Partnerships are Key to Success



- Internal DER/DOE
  - Technology Programs (microturbines)
  - Industrial Distributed Generation Program
  - CHP and Integrated Energy Systems
  - Federal Energy Management Program
  - Office of Industrial Technologies
- External Coordination
  - California Energy Commission (Low Emissions)
  - NASA (Materials)
  - DoD (Materials)
  - EPA (CHP Partnership and air permitting issues)

# Technology Characterizations

- Develop credible, peer-reviewed technology characterizations (TCs) for OPT's gas-fired and renewable DER technologies.
- The TCs will present comprehensive data and information describing the current status and future potential of the technology in a uniform and consistent manner.
- Projection of future cost and performance feed into: GPRA Analysis, Scenario development, Congressional Q&As, Stakeholders and provide a sound basis for program planning, policy analysis and deployment.

# TC Schedule

- Develop TCs for six gas-fired DER technologies by April as follows:

## **Small gas turbines**

Sterling Engine

Fuel Cell

## **Recip Engines**

Steam Turbine

Micro Turbine

- Comments are welcome and should be sent to:

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[Larry\\_goldstein@nrel.gov](mailto:Larry_goldstein@nrel.gov)

# Summary

- Gas turbines will continue to play an important role in the Energy future of the United States by providing clean, reliable, and environmentally-friendly power for the new millennium
- Gas Turbines will be a strong competitive option for distributed power
- Materials and combustion technology is a key enabler for advances in gas turbines
- Continued government/industry collaborations will leverage our resources and advance technologies